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ABSTRACT

The issues of portability and re-use are key challenges for learning technology. A major effort has been directed toward the development of standards that will enable interoperability and the re-use of learning objects. This paper provides a critique of this work from a pedagogical perspective. It argues that true portability and re-use cannot be achieved based solely on a technically inspired drive towards standardization. A theoretical framework is required that will guide the process of analysis and synthesis. The paper proposes the basis for such a theoretical approach based on the concepts of layering and learning contexts. A formal approach to capturing the essential features of these learning contexts is outlined, based on the idea of design action potential networks. The choice pathways in these networks represent a formal description that may be fed into the standardization process. The ensuing descriptive data, attached as metadata to learning objects, would provide a pedagogically informed basis for interoperability and re-use. (Contains 18 references.) (Author/MES)

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TOWARDS A PEDAGOGICALLY SOUND BASIS FOR LEARNING OBJECT PORTABILITY AND RE-USE

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Abstract

The issues of portability and re-use are key challenges for learning technology. A major effort has been directed towards the development of standards that will enable interoperability and the re-use of 'learning objects'. The paper provides a critique of this work from a pedagogical perspective. It argues that true portability and re-use cannot be achieved based solely on a technically inspired drive towards standardization. A theoretical framework is required that will guide the process of analysis and synthesis. This paper proposes the basis for such a theoretical approach based on the concepts of layering and learning contexts. A formal approach to capturing the essential features of these learning contexts is outlined, based on the idea of 'design action potential' networks. The choice pathways in these networks represent a formal description that may be fed into the standardization process. The ensuing descriptive data, attached as metadata to learning objects, would provide a pedagogically informed basis for interoperability and re-use.

Keywords

e-learning, metadata, standardization, portability, re-use

Introduction

Educational and training institutions have expended considerable energy on developing computer based educational material, which can take the form of anything from a simple file to a full set of online courses. Globally, e-learning is estimated to be worth $365 Billion by 2003 (Moe & Blodgett, 2000). Major UK public sector developments alone include the University for Industry, the National Grid for Learning, the e-university, and the Distributed National Electronic Resource (online). However, there is a fundamental problem in the fragmented and disjointed way these materials are structured and stored in online resource repositories. From the user's perspective, the potential offered by all of this content is diluted by the disjointed, poorly structured manner in which material is being placed online. From an organizational perspective, the structural deficiencies may act as a disincentive to investing in large-scale e-learning solutions. Essentially what is needed are standards that allow educational materials to be reused in an educationally meaningful way.

Reusability in e-learning presupposes that educational materials are described in a systematic way that facilitates the identification and integration of various learning materials. This leads naturally to ideas of standardization and classification. However, standardisation is particularly difficult to achieve in inherently decentralised domains.

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The first part of this paper provides a selective, critical review of the major standardization initiatives based on the concepts of 'learning objects' and metadata. This work has been developing a technical basis for the re-use of learning materials. The work aims to produce a basis for interoperability. Interoperability is here defined primarily as the ability to operate multi-vendor components together using a common set of protocols or standards. The basic approach is to attach metadata, extra descriptive material, to learning objects to support location, description and re-use. This discussion on learning object standardization highlights the pedagogical weakness of the approaches adopted. It concludes that true portability and re-use cannot be achieved based solely on a technically inspired approach towards standardization. Standardization for re-use requires a pedagogically informed theoretical base to underpin the descriptive standardization process.

The second part of the paper explores the basis on which a theoretically sound approach to capturing pedagogical attributes may be developed. It proposes the basis for such an approach based on the concepts of layering and learning 'contexts'. It first outlines these concepts. The paper then explores their potential contribution to enriching the formal standardization process.

Critical Review of Work on Learning Object Standardization

The current state of play in terms of standards for the repositories of learning objects is problematic. Content is currently described using a wide range of standards and specifications, including a confusing mix of emerging international specifications (Miller, 2001). Important developments in this field include the IMS Metadata Specification (online) and closely related LOM from IEEE (online), the Dublin Core Metadata Element Set (online) and proposed educational extensions (online), and locally developed alternatives. These technical problems are obscuring a more fundamental pedagogical problem, namely that these standards have barely considered how to underpin developments in a theoretically sound way.

The standards developed are based on the idea of attaching metadata to learning objects. Metadata is 'data about data'; it involves the addition of extra information that describes the nature and structure of the learning object. The metadata should allow computers processing software to 'understand' the structure of a resource and the relationship between the objects inside the resource. This would facilitate resource discovery:

> "The association of standardized descriptive metadata with networked objects has the potential for substantially improving resource discovery capabilities by enabling field-based (e.g., author, title) searches, permitting indexing of non-textual objects, and allowing access to the surrogate content that is distinct from access to the content of the resource itself." (Weibel & Lagoze, 1997)

The metadata attached to learning objects should also provide information to support the re-use of objects. To achieve these twin aims a metadata model is required. Such a model describes the learning object structure, and needs to be applied when the resource is created. Should another course author wish to reuse a particular learning object, they first need to locate it (resource discovery). Thus, the same metadata model that was specified when the object was created is used when a search is performed to locate appropriate resources. The metadata should then provide information to support the re-use of the learning object in the new setting. Within one resource, e.g. a local database, it is easy to enforce a particular metadata model. However, when one considers the number of resources in a multitude of dissimilarly structured repositories residing all over the globe, and in a variety of different human languages, then the problem increases exponentially in complexity.

Solving the complex task of finding and using disparate sets of learning objects is described as interoperability. Interoperability is a precondition for reusability; it supposes a framework or language-like structure in which the meanings of dissimilar metadata descriptions could be conveyed between two or more systems. True interoperability would free the course construction activity of time consuming search and crop-to-fit exercises (i.e. customizing located material to fit

the educational objective at hand). The assumption is that the objects within the resource could be described to stand alone as well as to be a part of a bigger object, which in turn could be contained by a bigger object, and so on. This flexibility would grant the possibility of construction of entire courses by integration of various sets of metadata referenced materials. One author's effort could be integrated in numerous learning systems. However, the question as to whether this would improve the overall quality of learning materials is not clear. A full review of the general approach to inter-domain interoperability is beyond the scope of this paper. Interested readers are referred to EASEL (online) for more information

There is a significant problem with current approaches. These approaches to standardization have taken a strongly technological approach to solving the problems of reuse and recombination. Learning objects are described as 'pedagogical neutral' (Cowley & Wesson, 2000). The formal descriptions (metadata) do not have a strong pedagogical base. Metadata provides ways of locating objects and linking them like pieces in a jigsaw. There is no guarantee, however, that the jigsaw will make pedagogical sense. The metadata information may be extended to include information about the instructional role of the learning object (Hepburn & Place, 2000). However, there are limitations to the use of adding descriptive data without a clear theoretical base.

Towards A Pedagogically Sound Base for Re-Combination and Re-use

The paper now turns to the issue of how such a theoretically informed approach to the analysis and description of 'learning 'objects' might be derived. The first problem is that the concept of 'learning objects' is theoretically weak. We need a better understanding of how we might conceive of computer based learning entities (the term 'entity' is chosen to be as general as possible at this stage). This paper will discuss two major issues in developing the proposal for a better-informed approach to analysis and re-use:

- the conceptual representation of 'learning entities'
- relationships between learning entities

The Central Explanatory Construct For Capturing E-learning Artefacts

'Things separate from their stories have no meaning'

The Crossing – Cormac McCarthy

Hodges and Sasnett (1993), arguing from a film theory perspective, have proposed that context is the natural unit for understanding and representing computer-based multimedia environments. They initially compare a computer-based environment to a scene in a film. The key difference in a computer-based situation is the addition of interactivity. They argue that the concept of 'context' can both capture concepts from traditional film theory and enhance this understanding through the addition of the concept of interactivity. From this perspective a context might be visualized as an interactive scene.

Boyle, approaching from a different perspective influenced by psychology and linguistics, proposes that computer-based learning entities should be conceptualized not as things (objects) but as learning 'contexts' (Boyle 1997, 2000). Context is here defined as a construction that makes selective, holistic sense of the environment of interaction. This 'construction' guides adaptive action in the environment. This concept emphasizes the central role of appropriate activity. The central challenge for educational multimedia designers is to create contexts that promote effective interactive learning. Specific guidance on how to achieve this goal is given in several contributory disciplines, especially linguistics, situated action theory, film theory and psychology. The contributions from film theory, linguistics and psychology are developed in some detail in Boyle (1997).

The influences from psychology and film theory provide a rich base for articulating learning contexts. However, it is the input from linguistics that provides the basis for the formal description that is necessary to capture their essential features. Systemic Linguistics views natural language

grammar as derived through a series of abstractions from the use of language in context. It has developed a formal systematic representation of this (context grounded) deep grammar based on 'systemic networks' (Halliday, 1973, 1975). Boyle (1997) adapted this approach to develop a method of capturing the design choices built into computer-based learning environments. He argues that the creation of multimedia learning contexts involves the parallel choices made on three macro-functions:

- the *content structuring* macro-function: the selection and structuring of the learning content in the multimedia context;

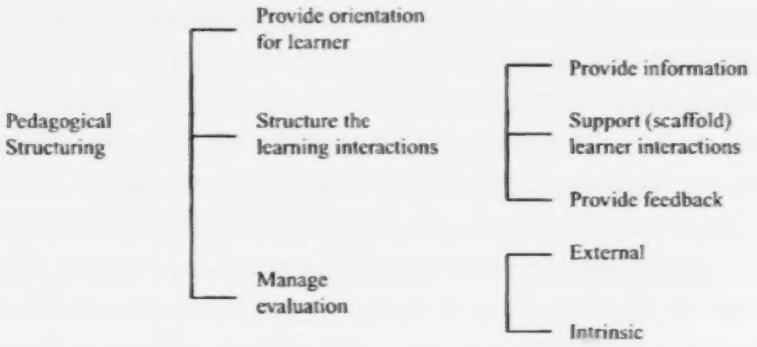

Figure 1(a): An initial analytic framework for pedagogical decisions

- the *interactivity* macro-function: designing for user interaction with this content;
- the *compositional* macro-function: the creation of a coherent overall composition, both within and across contexts.

Boyle proposes that these choices can be represented in 'design action potential' (DAP) networks that capture the design choices made. These networks follow a similar structure to the systemic networks used in linguistics to capture progressively more delicate levels of linguistic options. Choices on the three macro-functions are expanded in parallel networks. Figures 1(a) provides an example of the expansion of the high level 'interactivity' macro-function. Figure 1(b) expands the alternative options available under the 'Provide Orientation' node. Examples of expansion of the content structuring and compositional functions are provided in Boyle (1997).

There are strong correspondences between the first two macro-functions and the traditional educational concerns of curriculum (the structuring of the content to be learned) and pedagogy (the structuring of learning interactions). The macro-functions thus synthesize contributions from a number of significant contributory disciplines. These contributions tend to complement one another, and provide a richer picture for the e-learning designer. The third macro-function has no marked parallel in educational theory, but the contributions from linguistics and film theory help to fill out this concept.

It is not the role of this paper to go into a detailed exposition of this concept (see Boyle, 1997). However, it does point to a significant research challenge: how to capture in a systematic, unified knowledge base the sophisticated options in constructing educational multimedia contexts. This formal system could provide the theoretical base in providing an informed extension to metadata schemes which would capture the pedagogical richness of computer based learning entities. Such knowledge might be attached to re-usable learning objects to mark the choices of content structuring, interaction and composition they embody. This would greatly enhance the educational use of learning objects which are at present pedagogically limited (Cowley & Wesson, 2000; Hepburn & Place, 2000).

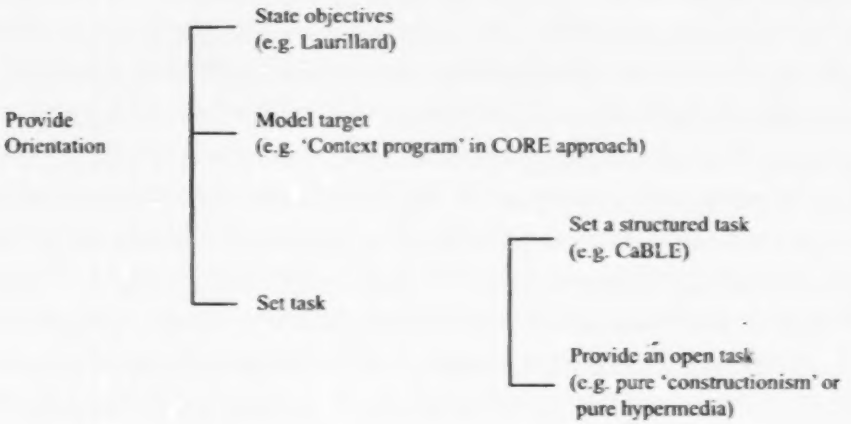

Figure 1(b): An elaboration of the 'provide orientation' function

Relationships between Learning Contexts

'... and each tale the sum of the lesser tales'

The Crossing – Cormac McCarthy

A second significant challenge is how to capture in a meaningful way the relationships between learning contexts. This is a rich topic. The aim of this section is to focus on one significant type of relationship rather than to explore this area fully. The 'learning objects' approach tends to be very eclectic in defining what a learning object is. It may be a whole module, or it may be a specific learning resource. The theme of this section is that there is considerable analytic power to be gained from analyzing learning objects into different layers, and in clarifying the relationship between objects at these layers. This section will illustrate how this may lead to a more powerful basis for the re-use of learning contexts.

The simplest 'layered' approach to re-use is 'resource-based learning' (Hall, Hutchings, & White, 1995). In this model there are basically two layers – a resource layer and a layer of use. Resources are held on computer systems; these may be searched by tutors for use in their classes. Tools, such as Microcosm, have been developed to support this process. Theoretically, this approach is weak. The human tutor makes all the key pedagogical decisions. There is little explicit pedagogical information captured about the resources at the computer/resource layer. The 'resource' layer, however, provides an important component of a more generalized approach to the layering of educational entities.

Boyle (2000) has outlined a minimum of three layers for capturing the pedagogical nature of computer based learning entities. The layers he proposes are:

Classware
Courseware
Resources

Courseware covers significant, self-contained curriculum areas, e.g. a set of web pages covering the content for a substantial part of a module that students are studying. For example, the CLEM system provided a fairly complete coverage of a first year university course in the programming language Modula-2 (Boyle, Stevens-Wood, Zhu, & Tikka, 1996). Resources are much smaller entities that deal with particular issues or functions.

This conceptual division might be best elucidated through an illustration of a system that is explicitly structured in this way.

Illustration of Layered E-Learning Contexts

The DFML Web based system (Boyle & Payne, 1999) was developed to complement the book 'Design for Multimedia Learning' (Boyle, 1997). Figure 2a is a screen from the system. The site was constructed to support very rapid navigation from a section in the book to the equivalent section on the Website. The site does not attempt to duplicate the book. It gives access to multimedia resources that expand and illustrate the abstract points made in the book. The panel on the left permits rapid drill down navigation to any section in the site (Figure 2a). The central panel then displays the key points from that section in the book. Opposite each paragraph there may be a link to multimedia resources that illustrate/expand on the key point made in the paragraph. The main context thus provides controlled access to other contexts, which have their own framing of content and interactivity. Figure 2b shows one of these contexts activated.

The DFML site is based on a very explicit 'levelling' of contexts. The main site operates at the courseware level – it covers a substantial curriculum area for a module on interactive multimedia design. The 'micro-contexts' act at the next level down – 'resources'. These learning contexts deal with specific themes or issues, e.g. using illusions to illustrate the active nature of perception. The interface between the two levels is kept very clean. It is managed through specific links kept on a separate part of the courseware context screens. This greatly aids portability and re-use. The resource contexts can all be used independently from this particular courseware context.

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Perception is highly active and constructive process. It involves the interaction of two sources of information: information from our senses, and accumulated knowledge stored in memory. Presentation design can be informed by an understanding of how this active constructive process works.
A major influence on perception is expectancy: we should design activities so that the users can deduce patterns that enable them to form accurate expectations. This supports the user in forming expectations that guide accurate perception
Perception is strongly orientated to the perception of patterns. The Gestalt psychologists identified many pattern-based phenomena. Their primary insight is summarised in the phrase: 'The whole is greater than the sum of the parts'.

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Figures 2 (a) and 2 (b): The DFML screens

The courseware context in turn 'plugs in to' the (higher level) classware level context, as exemplified in a VLE such as WebCT. This permits the multimedia courseware context to be incorporated in a wider virtual classroom with organized discussion groups, etc. The construction of learning contexts can thus be structured on a series of levels. If the interfaces between these levels are kept as simple as possible this greatly facilitates re-use and re-combination.

The purpose of this paper is to sketch a programme for tackling the issue of pedagogically informed portability and re-use. It is beyond the scope of this paper to go into a detailed unfolding of the primary theoretical constructs. It is, however, important to comment on the link between this type of theoretically informed analysis and the forms through which standardization is expressed. The DAP networks record formally the choices made in the design of learning contexts. They provide a theoretical base to work from. The full conceptual expansion of this base remains a research task. The precise descriptions generated by this task, however, would provide rich descriptions of pedagogical design features. These descriptions are highly amenable to capture in terms of the metadata structures used in standardization research. These contextual descriptions would greatly enrich the pedagogical information captured in the standardized metadata. It is proposed that these metadata extensions, together with the 'layer' marking of the learning entity, would greatly enhance the re-use and re-combination of learning 'objects'.

Conclusions

How to solve the 'analysis-synthesis' nexus that is the core challenge for the effective re-use of learning materials? This paper has provided a critique of the present state of the learning objects approach. The focus on learning objects is more on the 'mechanical' re-use of pre-formed chunks by selecting these from catalogues of learning objects. The theoretical weaknesses of this approach undermine its ability to solve the deep problems of re-use and re-combination.

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The paper has set out an analysis of some of the principal issues in tackling the problem of pedagogically informed re-use. It has proposed the notion of learning 'context' to capture the richness of e-learning environments. The design feature of these contexts may be captured formally in networks similar in structure to systemic networks in linguistics. The information captured in these networks provides a basis for extending the metadata about learning 'objects'. This provides a more informed basis for re-use. The importance of layering learning contexts has also been emphasized in separating contexts for re-use in different settings.

Building a firmer base for the re-use of computer-based learning resources requires a systematic and formal discipline. This process should not only lead to better systems for re-use; it should also make a significant contributions to a deeper theoretical understanding of the nature of computer based learning environments.

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